



Multi-Purpose Crew Vehicle Program Update

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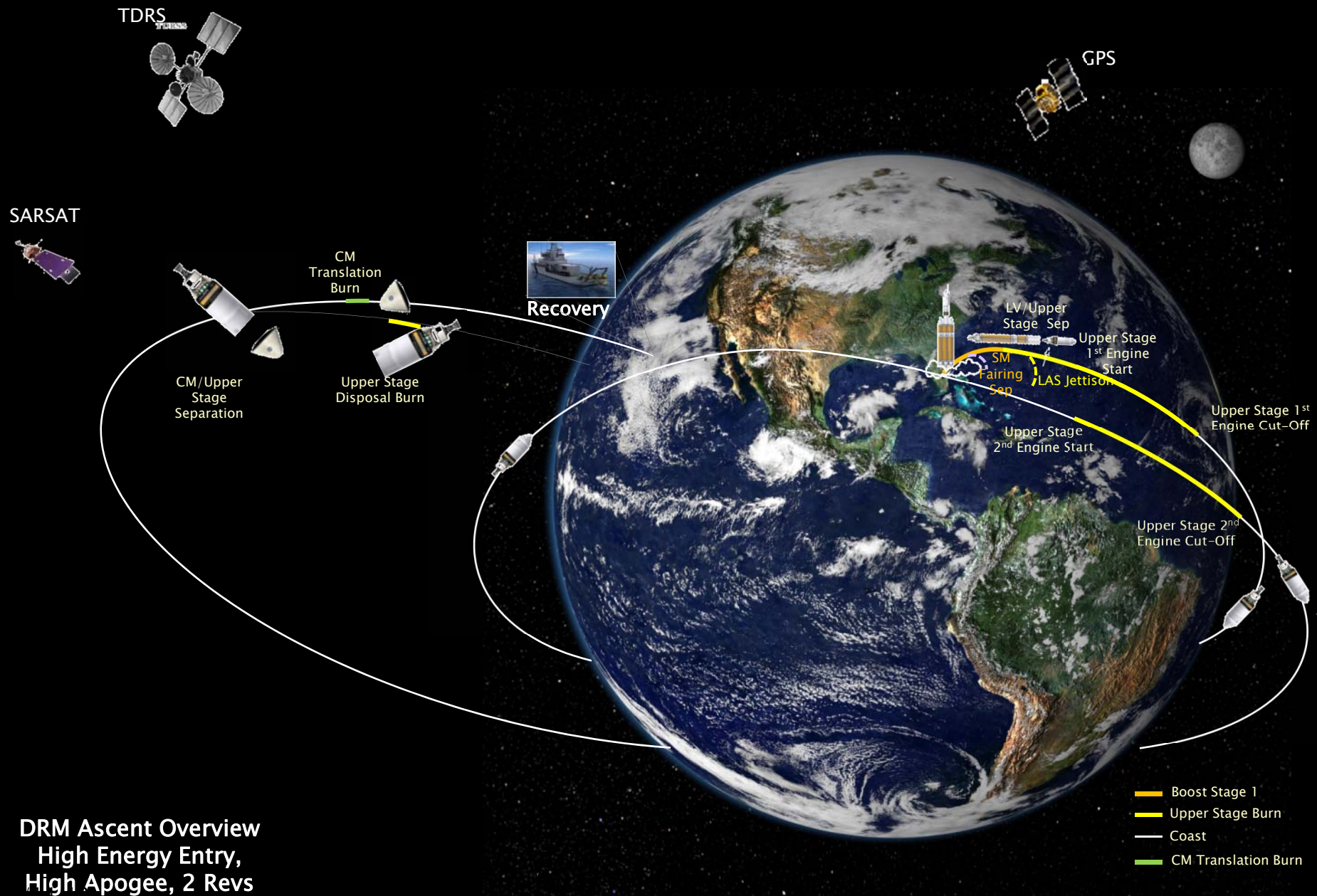
NWS/Spaceflight Meteorology Group

Natural Environments Day-of-Launch Working Group
20 March 2014



Orion Exploration Flight Test 1 (EFT-1)

Orion EFT-1 Mission Overview





Key Mission Parameters

- ▶ Orion EFT-1
 - Launch site: Kennedy Space Center, FL
 - Launch vehicle: Delta IV Heavy (Delta IV-H)
 - Expected launch date: September 2014
 - Mission duration: 4.5 hours
 - Landing site: off coast of Baja peninsula

- ▶ EFT-1 work related to potential natural environment placards for launch/landing, including develop of Launch Commit Criteria (LCC) and a Program Requirements Document (PRD), continues.
 - Decision at 12 February 2014 Orion Vehicle Integration Team meeting was to not pursue any change in wind placard from the DSNE surface wind limit already assumed.
[DSNE nominal mean wind speed value = 8.2 m/s (15.9 knots)]



EFT-1 Program Schedule Update



- ▶ Stationary Test [August 12–16, 2013] **COMPLETED**
 - USS Arlington in port at Norfolk, VA.
 - Successful test communication of weather data back to JSC/SMG.
- ▶ Underway Recovery Test (URT) [February 18–20, 2014] **COMPLETED**
 - Some primary test objectives were not met.
 - Capsule recovery operations in open sea were not demonstrated.
 - Possibility for URT-2 and maybe URT-3 being discussed.
 - Weather test objectives were successful.
 - Surface weather and wave observations from Navy personnel transmitted to MCC/SMG.
 - Weather balloon launches from USS San Diego. Data distributed to onboard users and transmitted to MCC/SMG.
- ▶ Crew Exploration Vehicle (CEV) Parachute Assembly System (CPAS) testing continues at Yuma Proving Ground in Arizona leading up to EFT-1.
 - Latest test was on 26 February 2014.
- ▶ EFT-1 launch date: September 2014



EFT-1 Upper Air Requirements

- ▶ Orion Flight Test Objectives evaluation and Best Estimate Trajectory construction conducted post flight.
 - Not real or near-real time. Provide data after the mission.
- ▶ Ground Ops
 - Real or near-real time data required at the recovery site.
- ▶ Mission Ops
 - Highly desirable for real or near-real time data.
 - MOD will produce a post-burn EFT-1 capsule Trajectory update.
 - Will produce a prediction of an EFT-1 capsule descent state vector at 50K ft (TBR).
 - No real-time wind data required for above or below 50K ft.
 - Data transfer in near-real time to JSC/MCC, SMG and others expected to be possible at no or trivial cost. E-mail !!



Underway Recovery Test



Photo credits: NASA

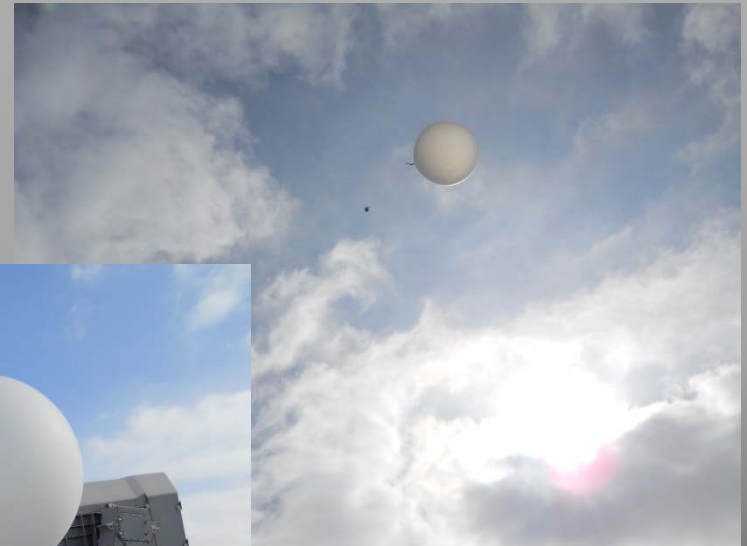


Photo credits:
Mark Hendrickson,
YPG Met Group



URT Balloon Data Schedule



- ▶ **Day 1 at sea (18 Feb) :**
 - Vaisala check out flight.
 - IMET-3150 check out flight.
 - Inter-comparison flight test.
- ▶ **Day 2 at sea (19 Feb):**
 - IMET-3150 and Vaisala flights separated by approximately 3 hours.
 - Simulates decision point for Sasquatch tool user to choose between using last available landing forecast wind profile and TD-2:45 hour balloon.
- ▶ **Day 3 at sea End-to-End Test (20 Feb):**
 - TD – 8:25 hours (L-4:00) (JSC/SMG)
 - Aid upper wind profile forecast for splashdown (TD-0).
 - Supports pre-launch Heading Alignment input.
 - Initial splashdown prediction post SECO-2.
 - TD – 2:45 (L+1:40) (GO)(JSC/DM)
 - Sasquatch tool input for debris avoidance.
 - Updated splashdown prediction.
 - TD – 1:40 (L+2:45) (LM)
 - Post-process trajectory reconstruction.
 - Persistence calculations and backup for possible subsequent failures.
 - TD – 00:55 (L+3:20) (LM)
 - Post-process trajectory reconstruction.
 - CM & balloon near 45kft.
 - TD – 00:10 (L+4:15)(LM) (JSC/SMG)
 - Verification balloon.
 - Input for Best Estimate Trajectory.
 - Post-process trajectory reconstruction.
 - Balloon should be at roughly same altitude as CM at main parachute deploy.

9 rawinsondes released:
2 IMET
7 Vaisala



EFT-1 Upper Air Systems Vaisala MW31 / RS92-SGP



- ▶ Yuma Proving Ground (YPG) Met Branch:
 - Same system used for NASA CPAS tests at YPG.
 - Familiar personnel, data formats, equipment, etc.
 - “Worked flawlessly, just like back here on land”.



Upper air equipment

Photos courtesy of Mark Hendrickson, YPG

Work area with Vaisala receiver and laptop





EFT-1 Upper Air Systems IMET-3150 / iMET-1-ABx



- ▶ Inexpensive.
- ▶ Evaluate for use in EM1, EM2 and subsequent missions.
- ▶ Worked similar as it did on land.
- ▶ Operator issues:
 - Short cable length from antenna to receiver to laptop makes it less practical to track the sonde.
 - User must get permission to roam around the ship to maintain signal. Cannot simply mount and track the sonde.
- ▶ Data gaps:
 - Appears system simply averages and smooths data.
 - No discernible data loss alert.
- ▶ Operational analysis and recommendation for future use forthcoming.



Photos courtesy of Mark Hendrickson





Balloon Release Area



Magnetic antenna
mounts for Vaisala
system

Photos courtesy of Mark Hendrickson



Release area





Upper Air / Weather Support Issues and Lessons Learned

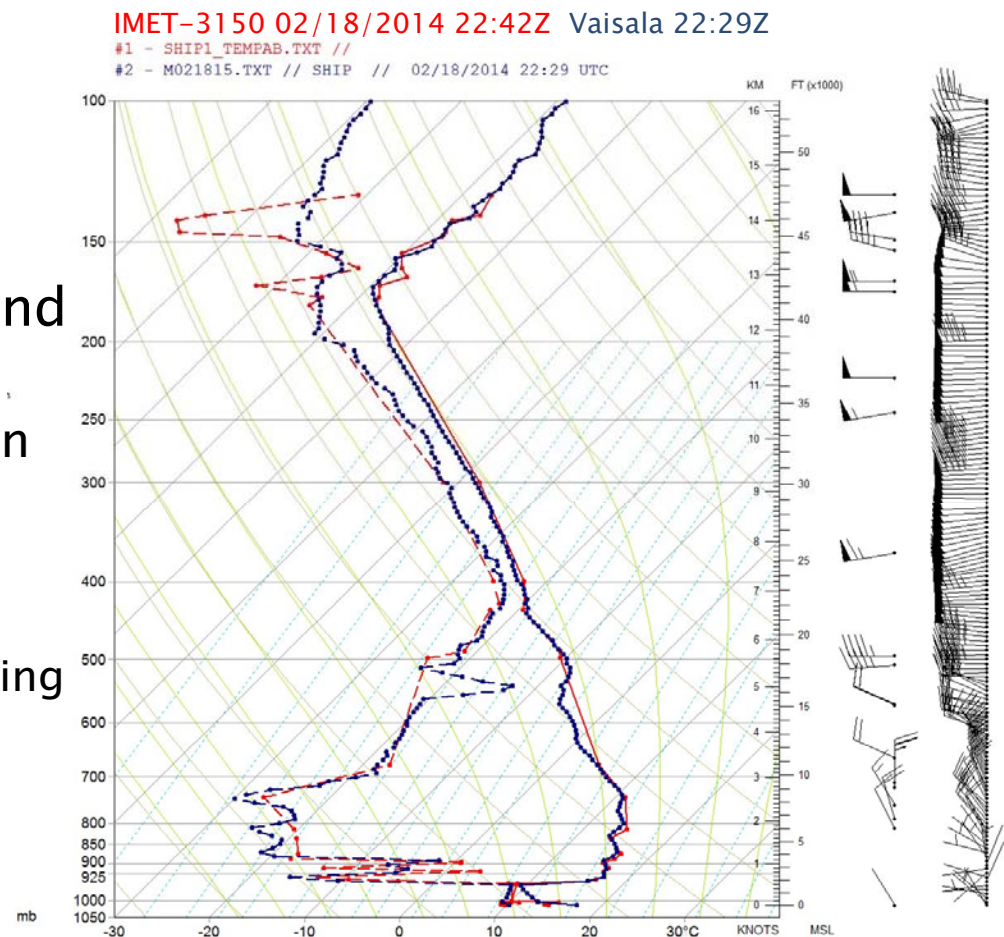


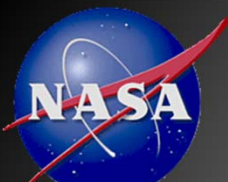
- ▶ E-mail communication worked well.
 - Upper air and surface weather data files are very small.
 - Voice loop comm backup.
 - Manual transfer of e-mail attachment data files to MIDDs and other locations.
- ▶ “River City” – planned communication outages only hiccup in data comm plan.
 - Request weather exemption from planned data outages.



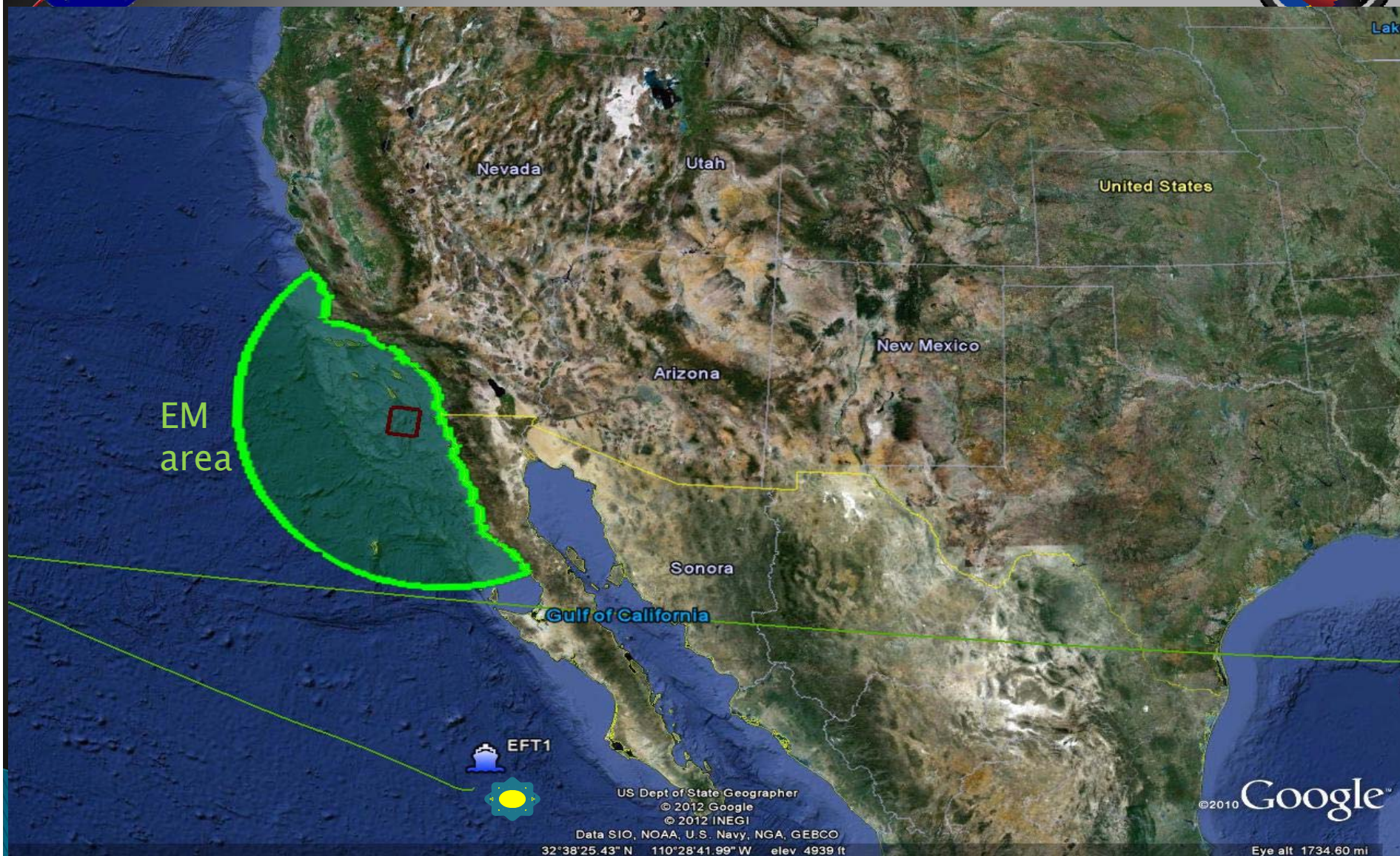
Forward Work

- ▶ Complete evaluation of IMET-3150.
- ▶ EFT-1 and EM weather Flight Rule development.
- ▶ Further evaluation of upper wind forecast accuracy.
 - Improve estimate of splashdown site wind profile.
 - GDAS or other model analysis at time 0 versus GFS initialization.
 - Evaluate at proposed future landing location versus EFT-1 location.
- ▶ Continued operations procedures development and documentation.





Splashdown Locations





Exploration Missions 1 & 2 (EM-1 / EM-2)



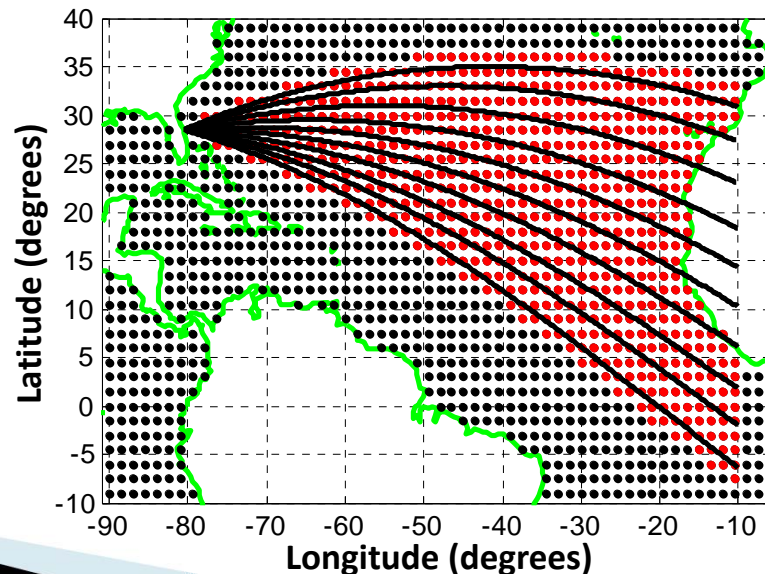
Orion EM Program Schedule

- ▶ European Service Module Program Design Review (PDR) is scheduled for late spring/early summer 2014 ahead of Orion delta PDR.
- ▶ Orion delta PDR to occur mid-summer 2014.
- ▶ Orion Critical Design Review expected to occur August 2015.
- ▶ Current Mission Schedule (tentative):
 - EM-1 scheduled for 2017.
 - AA-2 scheduled for 2018.
 - EM-2 scheduled for 2021.



Orion EM Technical Work

- ▶ Support Lockheed Martin as they are now on contract for SLS-SPEC-159 Baseline DSNE for EM missions.
 - This version includes specification to use Earth-GRAM 2010.
- ▶ Need to protect for natural environments along an ascent abort groundtrack that could cover anywhere in the Atlantic Ocean between 35° northerly and 32° southerly launch azimuths.
 - EV44 looking at launch availability based on DSNE specifications.
 - SMG will look at tropical cyclone statistics for the Atlantic ascent abort zones and the Pacific abort-once-around zone.



- area under groundtracks to be evaluated for natural environments (including sea states)



Orion EM Forward Work

- ▶ Continue to support Landing & Recovery testing and analyses.
- ▶ Support development of integrated Operations & Maintenance Requirements (OMRs).
- ▶ Support Orion EDL/GN&C EM Design Analysis Cycle work.
 - Additional natural environment analyses are expected as Orion moves toward EM flights and nominal landings off the coast of San Diego.
- ▶ Support Orion launch/landing analyses.
 - Terrestrial environments will affect launch availability, landing availability, pad aborts.
- ▶ Support Orion Weather Flight Rule development for EM missions.
 - Instrumentation such as offshore buoys and 915 MHz profiler may be necessary to support flight rules.